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A Computation Model for Nanoantenna-based Solar Cell with High Conversion Efficiency

Yiyan Li, Liy10@unlv.nevada.edu
University of Nevada, Las Vegas

Co-Authors: Ke-Xun Sun, Yingtao Jiang, University of Nevada, Las Vegas, NV

The rapid onset of climate change threatens our very livelihood, and moving away from greenhouse-gas-emitting fossil fuels into clean, renewable energy sources seems to be the only viable option we have. Up to date, even with its rapid growth, solar power yet contributes a small portion of our energy needs, largely because of the problems associated with the traditional photovoltaic-effect based solar cells, such as low conversion efficiency, and dependence of electricity generation on the availability of sunlight. There are very limited studies showing that by incorporating nanoantenna structures into the solar cells, higher conversion efficiency can be achieved, as nanoantenna electromagnetic collectors can be configured to operate in almost the entire solar spectrum. Ideally in theory, yet a computation model is needed to fast and accurately examine various engineering design choices concerning the shape and the scale of the nanoantennas, and such a model is presented here. Rather than converting energy from photons to voltage as in traditional solar cells, photo-electrical conversion in nanoantenna-based solar cells is completed through generating alternating currents on the surface of the antenna by the incident optical electromagnetic field. This incident electric field excited current is modeled as the integration of the infinitesimal current elements which can be numerically computed through finite-different time-domain (FDTD) simulations. Result shows this modeling method can be applied to study conversion efficiency in nanoantenna-based solar energy collectors for the purpose of design optimization with complex geometries.